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Notes on Some Siphonaptera from Canada[1]

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In a previous paper on the Siphonaptera of Canada the writer (Holland, 1949b) summarized all available published and unpublished data up to December 31, 1946. One hundred and twenty-seven species and subspecies of fleas were recorded, of which 121 are believed to be endemic, and 6 introduced in historic times from the Palaearctic Region.

Studies since 1946 have drawn attention to the occurrence in Canada of a number of species not hitherto recorded. Some of these were new to science. The discoveries of some of the others could have been predicted with reasonable certainty, the species being known from areas immediately south of the International Boundary, on species of hosts known to occur in Canada. In other instances the captures occasioned some surprise, the Canadian records representing rather broad extensions of the known ranges. Some of this supplementary information has already been published (Holland, 1949a, 1950, 1951a, 1951b). In the present paper, seven additional species and subspecies are reported from Canada for the first time. In partial compensation for this, the total of Canadian species is reduced by the recognition of two synonyms.

The classification adopted in this list is based on that of Jordan (1948), pending the publication of a catalogue of the N. C. Rothschild Collection. It was one of the conditions of Rothschild's gift of his collection of ectoparasites to the British Museum (Natural History) that the Trustees should publish a catalogue of the specimens it contained. The catalogue of the fleas (which constitute the largest and most representative collection of the Order in existence) is now being prepared by Mr. G. H. E. Hopkins of the Zoological Museum, Tring, and the Honourable Miriam Rothschild of Ashton Wold, Oundle, and will almost constitute a monograph of the Siphonaptera of the world so far as systematics are concerned. It will make available to siphonapterists the opinions of Dr. Karl Jordan on the phylogeny of the Order. Meanwhile, no fully satisfactory classification is available.

Family *Vermipsyllidae*

Chaetopsylla lotoris (Stewart)

Trichopsylla lotoris Stewart, 1926, pp. 122-124. Fox, 1940, pp. 33-34; pl. 8, figs. 35, 37, 38; pl. 9, fig. 42. Fuller, 1943, p. 19.

Originally described from specimens collected at Olcott, New York, this species has since been recorded from Iowa, Maine, and North Carolina (Fox, 1940) and Pennsylvania (Fuller, 1943). Although occasional specimens have been recorded from grey fox and possibly other hosts, there seems no doubt that raccoons, *Procyon* spp., are the true hosts. However, present information suggests that the species does not occur throughout the range of *Procyon;* certainly many collectors have examined specimens of raccoons in the Pacific coastal region without taking this or any other species of *Chaetopsylla.*

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Canadian Record

ONTARIO: Brampton, 28.XII.49, ex *Procyon lotor* ssp., 3 ♂, 5 ♀ (D. Sutherland).

Family *Neopsyllidae*

Subfamily *Neopsyllinae*

***Catallagia mathesoni* Jameson**

Catallagia decipiens, Hubbard, 1947 (*partim*), p. 288 (*nec* Rothschild, 1915).
Catallagia mathesoni Jameson, 1950, pp. 94-96; figs.

The species was described from Quincy, California, the type series (12 ♂ and 13 ♀) having been collected from *Peromyscus boylii* (Baird). Additional specimens were recorded from Quincy or nearby localities, ex *Clethrionomys californicus* (Merriam), *Microtus montanus* (Peale), *Neotoma fuscipes* Baird, and *Sorex trowbridgii* Baird. Hubbard (1947, p. 288) recorded "*Catallagia decipiens* Rothschild" from a number of localities in Washington, Oregon, and California; but a male and a female from Tule Lake, California, 4.I.42, ex *Peromyscus m. gambeli* Baird, labelled and recorded by Hubbard as of this species, are referable to *mathesoni*. Another pair, from Medford, Oregon, 31.XII.41, ex *Peromyscus truei gilberti* Allen, also labelled "*decipiens*" by Hubbard, are of *mathesoni*. However, as Hubbard's illustration (1947, p. 285) of the male genitalia of *decipiens* is correct, presumably some of his material was of that species. The writer has compared the above-mentioned specimens of Hubbard, and a pair from southern British Columbia, with paratypes and topotypes of *mathesoni*.

In southern British Columbia there is a marked difference in the flea fauna east and west of the Coast Range. In efforts to discover what occurred in intermediate areas lying in passes through these mountains, the writer frequently collected fleas at localities along the Fraser River where the "Interior Dry Belt" merged into the "Coastal Region". On one such occasion a male and a female of *Catallagia* sp. were collected from a white-footed mouse in a locality where the ranges of *C. charlottensis* (Baker) and *C. decipiens* Roths. might be expected to approach each other. The male flea was not typical of either of these species, and, indeed, exhibited some characters that were intermediate. It was difficult to decide whether this individual represented (a) a hybrid specimen, (b) an undescribed species, or (c) an abnormality of either *charlottensis* or *decipiens*. However, the recognition and description of *C. mathesoni* established the identity of the specimens.

Catallagia mathesoni appears to have a linear distribution, just east of the Coast Range, from British Columbia to California. Its range is flanked, and possibly overlapped, by that of *decipiens* to the east and by that of *charlottensis* to the west. The distribution of *C. sculleni* Hubbard probably overlaps at least part of that of *mathesoni*.

Canadian Record

BRITISH COLUMBIA: Chapmans, 30.IX.42, ex *Peromyscus maniculatus* ssp., 1 ♂, 1 ♀ (G. P. Holland).

***Catallagia borealis* Ewing**

Catallagia borealis Ewing, 1929 (March), pp. 126-127.
Catallagia onaga Jordan, 1929b (September), pp. 172-173; text-fig. 7 [*fide* Fuller, 1943, p. 22].

The species has been reported from Maine, New York, and West Virginia, from a variety of hosts including *Microtus p. pennsylvanicus* (Ord), *Blarina brevicauda* (Say), and *Clethrionomys carolinensis* (Merriam). The limits of distribution and true host affinities are unknown, the species being rare in collections. Like other neopsyllids, it is probably a nest flea.

Canadian Record

QUEBEC: Mingan, 31.X.47, ex *Clethrionomys gapperi proteus* (Bangs), 1♂, 1♀ (R. Traub).

Family *Hystrichopsyllidae*

Subfamily *Anomiopsyllinae*

In discussing and defining the Anomiopsyllinae the writer (1949b, p. 96) stated that five Nearctic genera of these nest fleas were recognized, of which three, *Callistopsyllus* Jord. and Roths., *Megarthroglossus* Jord. and Roths., and *Conorhinopsylla* Stew., were represented in the Canadian fauna. The remaining two, *Anomiopsyllus* Bak. and *Stenistomera* Roths., have now been discovered, one species of each having been collected from nests of wood rats, *Neotoma cinerea* ssp., in the Rocky Mountains of Alberta.

***Anomiopsyllus montanus* Collins**

Anomiopsyllus montanus Collins, 1936, pp. 129-130, 2 text-figs.

The species was described from specimens of both sexes collected from *Bubo virginianus occidentalis* (Stone) at Canyon Creek, near Hamilton, Montana. The owl was almost certainly an accidental host, as all the species of *Anomiopsyllus* are known to be parasites of rodents, particularly *Neotoma* spp. The Canadian material recorded here compares closely with a pair of near topotypes presented by Dr. Wm. L. Jellison of the Rocky Mountain Laboratory, Hamilton, Montana.

Canadian Record

ALBERTA: Banff, 20.XI.49, ex nest of *Neotoma cinerea* ssp., 3♂, 4♀ (H. U. Green).

***Stenistomera alpina* (Baker)**

Typhlosylla alpina Baker, 1895, pp. 189, 191.

Ctenopsyllus alpinus, Baker, 1904, pp. 427-428, 452.

Stenistomera alpina, Rothschild, 1915, p. 307. Good, 1942, pp. 133-138; pl. 13, figs. 1-3. Hubbard, 1947, pp. 305-306; figs.

Delotelis mohavensis Augustson, 1941, p. 138 [*fide* Hubbard, 1947, p. 305].

This peculiar species was described from specimens of both sexes collected at Georgetown, Colorado, from "mountain rat" [? *Neotoma* sp.]. Hubbard (1947) summarized the available information on hosts and distribution, listing the species from Montana, Colorado, Wyoming, New Mexico, Arizona, Utah, and California; of the various hosts, several species of *Neotoma* were the most frequent and evidently the most characteristic.

Canadian Record

ALBERTA: Banff, (no date), ex *Neotoma cinerea* ssp., 1♂ (H. U. Green); 20.XI.49, ex nest of *Neotoma cinerea* ssp., 1♂ (H. U. Green).

In the Rothschild Collection at Tring, Herts., England, there is a pair of *S. alpina* labelled "Red Deer R., Rocky Mountains, Canada, 1907, from *Mus sp.*, A. D. Gregson". [Author's note: "*Mus*" on the old Rothschild labels simply means "mouse".]

It is of interest that the wood-rat nest collected at Banff by Mr. Green contained, besides *S. alpina* and *A. montanus*, a number of specimens of *Megarthroglossus divisus* (Baker). Thus three of the five genera of the Anomiopsyllinae were represented in one collection! Also present, in large numbers, was *Orchopeas sexdentatus agilis* (Roths.). Wood rats are well supplied with fleas.

Family *Ceratophyllidae*

Subfamily *Ceratophyllinae*

***Megabothris groenlandicus* (Wahlgren)**

(Figs. 1, 2, and 3)

Ceratophyllus groenlandicus Wahlgren, 1903, p. 183; pl. 7, figs. 1, 2.

Megabothris groenlandicus, Jordan, 1933, p. 77. Holland, 1944, pp. 244-245; 2 figs. Holland, 1949b, p. 161; pl. 36, fig. 287; map 37.

Ceratophyllus immitis Jordan, 1929a, pp. 33-34; pl. 1, fig. 13. Jordan, 1929b, p. 175. *New synonymy.*

The species was described from a single male specimen, collected at Kaiser

Franz Joseph's Fjord, East Greenland, ex "*Myodes torquatus*" [*Dicrostonyx groenlandicus* (Traill)]. *Ceratophyllus immitis* was described from females [two specimens, although this was not mentioned by the describer], the locality data being given as "Canada: lat. 48045, VI.1846, from Lemming, probably *Dicrostonyx hudsonius*." This was a *lapsus calami*, the label on the type slide reading ". . . Lat. 48°45.N., 25 June 1846 . . ." Canada is not mentioned. An additional female bears identical data. Jordan (1929b, p. 175) suggested that the species might occur in the State of New York. However, the writer is satisfied that *immitis* is a synonym of *groenlandicus*, having compared the types of this species with specimens of the latter. As lemmings are undoubtedly the true hosts of these fleas, the type locality of lat. 48°45′ is impossible, for lemmings do not occur so far south. Jordan (*in litt.*) suggested that possibly long. 48°45′ was intended, which would suggest Greenland. However, this cannot be proved, so that, unless further information comes to light, the type locality of *immitis* must remain a mystery.

The Canadian National Collection contains several good series of both sexes of *M. groenlandicus* from arctic Canada. The writer has had the opportunity of comparing some of these specimens with a male from Greenland as well as with the type of *immitis*. Study of this material indicates that *M. groenlandicus* extends from Greenland and Baffin Island to the arctic mainland of Canada, where specimens are available from northern Quebec to the Mackenzie Delta. There appears to be no significant geographical variation, although there is a wide range of variability among individuals.

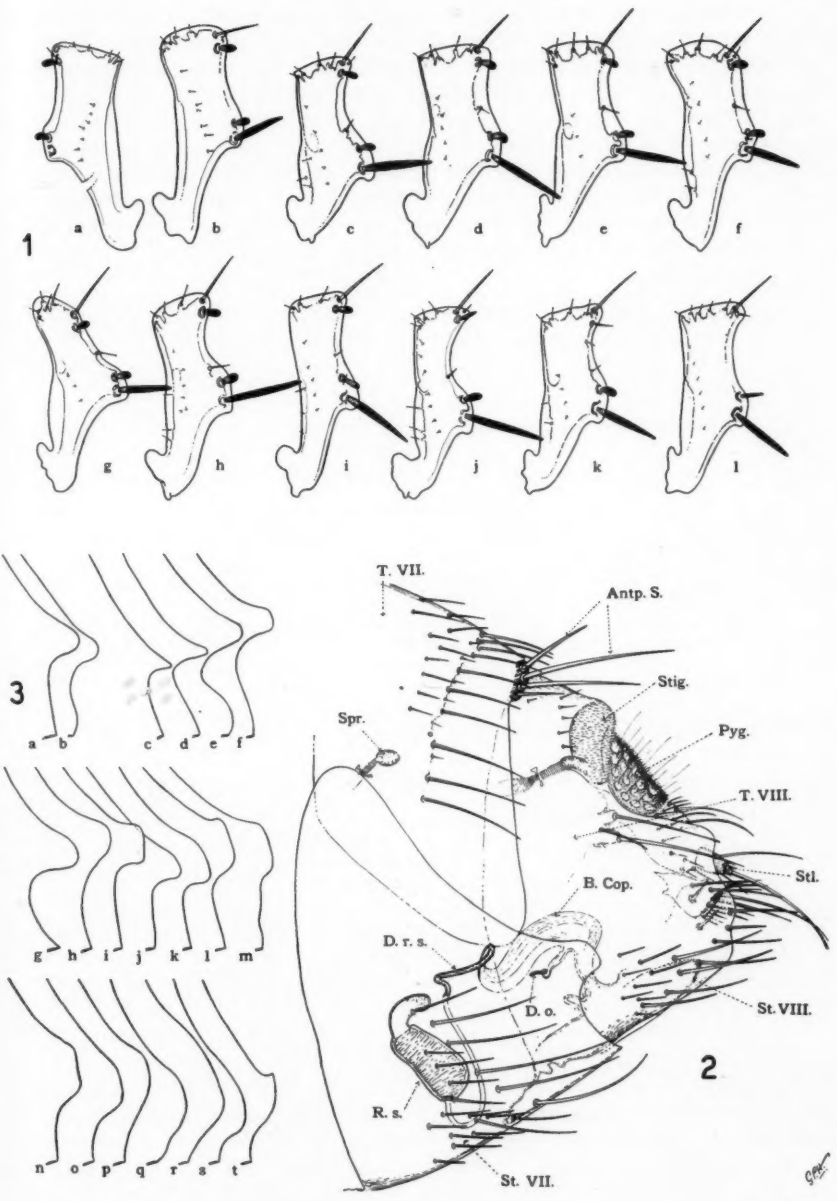
The flea has a truly arctic distribution, and species of both genera of lemmings (*Lemmus* and *Dicrostonyx*) are infested indiscriminately. Other rodents, e.g., *Microtus* spp., may be infested in areas where they occur in close association with lemmings. The species is not yet known from Alaska, Yukon, or northern British Columbia, where lemmings occur. It is not known from the Palaearctic Region, where both genera of lemmings are represented. In the Old World it is replaced perhaps by *Megabothris rectangulatus* (Wahlgren), which occurs on lemmings and mice. However, the association here is not so rigid, *M. rectangulatus* being known from a number of regions not truly arctic (Scotland, for example) and where lemmings do not occur.

Fig. 1 illustrates variation in the shape and armature of the movable process of the male claspers, a structure displaying great uniformity in many species. Fig. 1 a and b represent the right and left processes of a specimen from Scoresby Sound, Greenland. Fig. 1 c-l illustrate ten examples, all from one collection made at Great Whale River, Quebec. It will be seen that the length, breadth, contour, and proportions of the process vary considerably. The Greenland specimen is closely approximated in examples e, h, and i. Specimens j, k, and l demonstrate various degrees of reduction of one or both of the blunt spiniform setae, which tend to become bristle- or hair-like. Among 142 specimens examined, only five showed this reduction.

Some notes on the female are offered, to supplement the rather brief description of *immitis*.

Abbreviations

Antp.S.—antepygidial setae; B.Cop.—bursa copulatrix; D.o.—ductus obturatus; D.r.s.—ductus receptaculi seminis; Pyg.—sensilium (=pygidium); R.s.—spermatheca; Spr.—spiracle; St.—abdominal sternum; Stig.—stigma cavity of tergum VIII; Stl.—anal stylet; T.—abdominal tergum.



Figs. 1-3. *Megabothris groenlandicus* (Wahlgren). 1, Variation in movable process of male clasper: a and b, right and left processes of a specimen from Scoresby Sound, Greenland; c-l, left processes, selected from a series from Great Whale River, Quebec. 2, Terminal abdominal segments and genitalia of female, Great Whale River. 3, Variation in contour of sternum VII of female: a, type of *immitis* Jordan; b, another specimen from the type lot; c-t, a series from Great Whale River, Quebec.

Chaetotaxy and structure of head, thorax, legs, and anterior segments of abdomen are similar to those of the male, except for the usual sexual differences.

Tergum VII is like that of the male in that a number of setae of the posterior row are grouped fairly closely together between the two sets of antepygidial setae. There are three or four antepygidial seta on each side. Sternum VII exhibits much individual variation (Fig. 3), but in most specimens has a pronounced lobe and sinus. Examples a and b of Fig. 3 illustrate the type and paratype (?) of *Ceratophyllus immitis*. Examples c-t were selected from a series collected at Great Whale River, Quebec, and illustrate most of the variations.

Tergum VIII has a number of dorso-lateral, ventro-lateral, and marginal setae as illustrated (Fig. 2).

The spermatheca is of a shape common in this and related genera, and leads into the bursa copulatrix by means of a duct (ductus receptaculi seminis) which is sclerotized for part of its length (Fig. 2). The blind duct, or ductus obturatus, also is partially sclerotized.

Although it is, perhaps, the ecological replacement of the Palaearctic species *M. rectangulatus* (Wahlgr.), *M. groenlandicus* shows strongest phylogenetic affinities with the Nearctic species *M. quirini* (Roths.) and *M. lucifer* (Roths.).

Records

GREENLAND: Scoresby Sound, 1928, ex "*Myodes torquatus*" [*Dicrostonyx groenlandicus*] 1♂ (Alwin Pedersen).

NORTHWEST TERRITORIES: Pangnirtung, Baffin Island, 7.IV.45, ex *Lemmus trimucronatus* (Rich.), 1♂ (F. McInnes); Eskimo Point, 10-14.VI.50, ex *L. trimucronatus* ssp., 4♂ (G. R. Roberts); Chesterfield Inlet, 27.VI.-14.VIII.50, ex nests and burrows of lemmings (4 collections), 9♂, 26♀ (J. R. Vockeroth); 30.VI.50, ex nest of *Lemmus trimucronatus* ssp., 10♂, 24♀ (J.R.V.); 22.VI.50, ex *Dicrostonyx groenlandicus* ssp., 3♂, 5♀ (J.R.V.); 2.VI.-2.VIII50, ex *Lemmus trimucronatus* ssp. (6 collections), 9♂, 12♀ (J.R.V.); 5.VI.50, ex burrow of *Citellus parryi* ssp., 1♀ (J.R.V.); 10.VII.50, "on wet ground", 1♂, 1♀ (J.R.V.); Richards Island, 28.VII.47, ex *Dicrostonyx groenlandicus kilangmiutak* Anderson and Rand, 1♀ (I. McT. Cowan).

QUEBEC: Lake Tashwak, Ungava W., 27.VII.48, ex *Lemmus trimucronatus* ssp., 1♂ (R. Rousseau); Port Harrison, 8.VIII.49, ex "mouse nest", 1♂, 5♀ (D. P. Whillans); Great Whale River, 7.VI.-9.IX.49, ex *Microtus* sp. (4 collections), 18♂, 14♀ (J.R.V.); 10.VIII.49, ex nest of *Microtus* sp., 11♂, 6♀ (J.R.V.); 20.VI.-9.IX.49, ex *Dicrostonyx* sp. (5 collections), 38♂, 63♀ (J.R.V.); 16.VII.-10.VIII.49, ex nests of *Dicrostonyx* (2 collections), 5♂, 13♀ (J.R.V.); 5.IX.49, ex *Mustela erminea* ssp., 2♂ (J.R.V.).

MANITOBA: Churchill, 19.VI.47, ex *Dicrostonyx groenlandicus richardsoni* (Merriam), 1♂, 7♀ (T. N. Freeman); 26.VII.47, ex lemming, 1♂ (J. F. Sharp); 13.VII.49, ex *Microtus pennsylvanicus* ssp., 2♂ (G. P. Holland); 15.VII.49, ex *Dicrostonyx g. richardsoni*, 3♂, 1♀ (G.P.H.); 7.VII.49, ex "mouse", 2♂, 2♀ (J. B. Wallis); VI.-VII.50, ex *D. g. richardsoni*, 3♂, 9♀ (M. Merry); Fort Prince of Wales, 15.VII.49, ex nest of *D. g. richardsoni*, 4♂, 5♀ (G.P.H.).

***Megabothris clantoni* Hubbard**

Megabothris clantoni Hubbard, 1949a (September 22), pp. 141-143; 1 fig. Hubbard, 1949b, pp. 169-174; figs.

Megabothris princei Hubbard, 1949b, pp. 170-171; figs. *New synonymy.*

Megabothris obscurus Holland, 1949 (December 6), pp. 162-163; pl. 37, figs. 293, 294; map 37. *New synonymy.*

M. clantoni is undoubtedly a true parasite of the pallid vole, *Lemmiscus* [=*Lagurus*] spp. The type locality is Davenport, Lincoln Co., Washington, where large numbers of these fleas were collected from *Lemmiscus curtatus pauperrimus* (Cooper). In his second paper on this species, Hubbard (1949b, pp. 169-173) recorded additional material from other localities in Washington, and from California, Oregon, and Nevada. On the basis of the variation discovered in his specimens, he separated *M. clantoni* into two subspecies from the

same subspecies of host, the nominate race allegedly occupying territory on the east side of the Columbia River, and *M. c. johnsoni* territory on the west side. Material collected at localities in Oregon, California, and Nevada, near where these states meet, from *Lemmiscus c. intermedius*, he described as a species, *Megabothris princei*. The present writer feels that the distinctions claimed for *princei* are not sufficiently trenchant to warrant its specific status, and that at most it should be considered a subspecies of *clantoni*. Also, the presence on adjacent populations of one race of mouse of two clear-cut subspecies of fleas (*M. c. clantoni* and *M.c. johnsoni*) appears rather unusual; only a very few reliable cases have been recorded in the Siphonaptera. Fleas, like other ectoparasites, speciate slowly, so that a species or subspecies usually occupies the range of several subspecies or species of host without significant geographical variation. *M. clantoni* like *M. groenlandicus* (discussed above), undoubtedly exhibits considerable individual variability, as mentioned by Hubbard himself.

M. obscurus Holland, a synonym, was described from two males. The type, from Yakima Co., Washington (west of the Columbia), is intermediate between *M. c. clantoni* and *M. c. johnsoni* according to Hubbard's definition and figure of sternum VIII, which appears to provide the only character for separation. The paratype, from Stanmore, Alberta, is like *princei*. On the other hand, supporting Hubbard's contention, four males in the Canadian National Collection, from Grant Co., Washington (east of the Columbia), agree fairly well with *M. c. clantoni*, and one male from Yakima Co. (west) with *M. c. johnsoni*. Three males from Montana have the movable process of the clasper expanded at the apex somewhat as illustrated for *princei*. Two of these, one each from Toole Co. and Hill Co., have the upper short seta black and spiniform, but sternum VIII as in *M. c. clantoni*; the other male (Toole Co.) has the upper seta reduced, and sternum VIII like that of *princei* or *johnsoni*.

The question of subspecies in *Megabothris clantoni* undoubtedly requires further investigation, with an abundance of material.

Opisocrostis bruneri (Baker)

Pulex bruneri Baker, 1895, pp. 130-132.

Opisocrostis bruneri, Jordan, 1933b, p. 73. Fox, 1940, pp. 43-44; pl. 11, figs. 50, 51, 53. Hubbard, 1947, pp. 155-156; 1 fig. Holland, 1949b, pp. 127-128; pl. 27, figs. 205-206; map 25. *Ceratophyllus saundersi* Jordan, 1933a, pp. 16-17; text-figs. 6, 7. *New synonymy*.

Described from Lincoln, Nebraska, *Opisocrostis bruneri* has been recorded from Illinois, Iowa, Minnesota, Wisconsin, Idaho, Colorado, South Dakota, and Montana in the United States, and from Alberta, Saskatchewan, and Manitoba in Canada. The true hosts are ground squirrels, particularly *Citellus franklini* (Sabine), although the species is not infrequently taken from *C. 13-lineatus* ssp. and *C. richardsoni* (Sabine).

Opisocrostis saundersi (Jordan) was described from a short series collected at Saskatoon, Saskatchewan, ex *Citellus richardsoni*. Except for three females recorded by the writer (1949b, p. 129) the species has not been recognized again. As mentioned at that time, *O. saundersi* is very like *O. bruneri*, and the possibility was suggested that it might have been described from abnormal specimens of the latter. The differences between the females are stated to occur in the number of setae on sternum VII, a character apt to be variable. The figure of the male genitalia suggested the possiblity of abnormality. The writer has now had the opportunity of examining the type of *O. saundersi* and feels that it is simply a male of *bruneri* with the genitalia incompletely developed, an occurrence not uncommon in fleas and, in some instances at least, apparently caused by parasitic nematodes. The manubria of the claspers are not bilaterally symmetrical, and

the right manubrium suggests *bruneri* more than does the left (figured by Jordan). As typical specimens of *bruneri* have been collected at Saskatoon, and as diligent effort to rediscover *saundersi* has met with failure, it appears advisable to regard *saundersi* as a synonym.

Family *Leptopsyllidae*

Peromyscopsylla hesperomys hesperomys (Baker)

Ctenopsyllus hesperomys Baker, 1904, p. 428.
Peromyscopsylla hesperomys, Fox, 1939, p. 47. Fox, 1940, pp. 84-86; pl. 23, figs. 117-119.
Peromyscopsylla spinifrons Fox, 1939, p. 48; pl. 6, figs. 1, 2 [*fide* Fox, 1940, p. 84].

The species was described from Franconia, New Hampshire, on *Peromyscus* sp., and in typical form has been recorded from New York, Pennsylvania, Tennessee, and other localities in the eastern United States. White-footed mice are undoubtedly the true hosts.

A western subspecies, *Peromyscopsylla hesperomys pacifica* Holland, has been described from British Columbia, and also occurs in the adjacent State of Washington, and probably Oregon. *P. hesperomys hemisphaerium* Stewart occurs in California.

Specimens tallying well with near-topotypical material of *P. h. hesperomys* have now been collected from the following eastern Canadian localities.

Canadian Records

QUEBEC: Kingsmere, 11.IV.49, ex *Peromyscus* sp., 1♂, 2♀ (G. P. Holland).
ONTARIO: Belleville, 10.X.50, ex *Peromyscus* sp., 2♂, 1♀ (J. E. H. Martin); Milton, 22.IV.35, ex *Peromyscus* sp., 1♂, 3♀; 28.IV.35, ex *Peromyscus* sp., 1♂, 1♀ (D. M. Davies).

Peromyscopsylla scotti Fox

Peromyscopsylla scotti Fox, 1939, p. 49; pl. 6, figs. 4, 5.

Described from Dubuque, Iowa, ex *Peromyscus leucopus noveboracensis* (Fischer), the species has also been recorded from Massachusetts. The Canadian National Collection contains specimens from New York and Tennessee, presented by Dr. E. W. Jameson of the University of California, and Mr. Donald W. Pfitzer of the University of Tennessee, and one specimen from Canada.

Canadian Record

ONTARIO: Pelee Island, 7.III.46, ex *Peromyscus leucopus* ssp., 1♀ (K. Featherstone).

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Some Aphids of the Genus *Aphis* from the Maritime Provinces of Canada[1]

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Several writers (Baker, 1917; Patch, 1917, 1918, 1923) have published descriptions and keys for the aphids of the eastern United States. Many of these aphids are found in the Maritime Provinces of Canada. The only published list of the aphids of the latter area is that of Burnham (1938).

The following is a preliminary list for the Maritime Provinces of the aphids of the genus *Aphis;* collections have been made in various years since 1934. Notes on the dates of collections, hosts, and localities are given for most of the species.

Aphis abbreviata Patch.—This species has been considered by Theobald (1927) and Hottes and Frison (1931) to be a synonym of *Aphis rhammi* Boyer de Fonscolombe. Aphid taxonomists are not in agreement as to the status of these species.

In the Maritime Provinces it is found throughout the summer on *Solanum tuberosum* L. Alate and apterous viviparous females and alate males have been collected from this host. Oviparous females, alate males, and alate viviparous females have been collected from *Rhamnus alnifolia* L'Her. and *Rhamnus cathartica* L. in September and October. Apterous stem mothers and alate and apterous viviparous females also have been collected on these hosts between April and July. Viviparous females have been collected from *Chenopodium album* L., *Capsella bursa-pastoris* (L.), Medic., and *Zinnia* sp.

Aphis bakeri Cowen.—Alate viviparous females of this species were collected from *Malus pumila* Mill. at Fredericton, N.B., on October 8, 1948. *M. pumila* is recorded by Gillette and Palmer (1932) and Hottes and Frison (1931) as one of its winter hosts.

Aphis (*Anuraphis*) *cardui* Linnaeus.—Alate and apterous viviparous females of *A. cardui* were collected in June and September, 1941, on *Prunus nigra* Ait. in a few localities in New Brunswick.

Aphis (*Anuraphis*) *cerasifoliae* Fitch.—This species has been collected from *Prunus virginiana* L. during May, June, and July at Fredericton, N.B., since 1935. Alate and apterous viviparous females were present in these collections.

Aphis crataegifoliae Fitch.—Alate males and viviparous females were collected from *Crataegus* sp. at Fredericton, N.B., in October, 1948, and at Charlottetown, P.E.I., in July, 1941. Alate and apterous viviparous females were collected also from *Lathyrus odoratus* L. at Aroostook Junction, N.B., in July, 1950.

Aphis gossypii Glover.—Alate and apterous viviparous females of *A. gossypii* were found in heavy infestations on *Cucumis sativus* L. and *Spinacia oleracea* L. during June, 1948, at Barkers Point, N.B. This species was collected also from *Sedum purpureum* (L.) Link on August 2, 1934, near Fredericton, N.B.

Aphis helianthi Monell.—Alate and apterous viviparous females of this species were found in 1950 on *Cornus stolonifera* Michx. at Tidehead, Jacquet River, and Woodstock, N.B. Collections were made during June and July. At Tidehead the aphids were found in association with ants in the curled leaves and the flower heads of the host.

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Aphis (*Anuraphis*) *helichrysi* Theobald.—This species was recorded by Burnham (1938) from *Prunus* sp. collected in early October, 1936, at Fredericton, N.B.

Aphis maculatae Oestlund.—Alate and apterous viviparous females of this species were collected on *Populus tremuloides* Michx. at Woodstock, N.B., on July 18, 1950, and at Fredericton, N.B., on July 24, 1950. In the latter collection there were specimens of *Periphyllus populicola* (Thomas).

Aphis maidis Fitch.—Alate and apterous viviparous females of *A. maidis* were collected at Pokiok, N.B., on *Zea mays* L. and *Phaseolus* sp. in August, 1949. Burnham (1938) also recorded it from *Agrimonia* sp. collected near Fredericton, N.B., in October, 1936.

Aphis middletonii Thomas.—This species was recorded by Burnham (1938) from *Cornus* sp. collected at Fredericton, N.B., in October, 1936.

Aphis monardae Oestlund.—Burnham (1938) recorded this species from *Arctium minus* Schk. It was collected in New Brunswick in October, 1936.

Aphis (*Anuraphis*) *persicae-niger* Smith.—Burnham (1938) recorded this species from *Prunus nigra* L. collected at Fredericton, N.B., on September 14, 1936.

Aphis pomi DeGeer.—Alate and apterous viviparous females of this species have been collected throughout New Brunswick from *Malus pumila* Mill. since 1934 between June and September. It was also collected from *Sorbus americana* Marsh. at Marion Bridge, Cape Breton, July 2, 1950.

Aphis rubicola Oestlund.—Alate viviparous females of this species were collected from *Crataegus* sp. at Charlottetown, P.E.I. on June 28, 1937.

Aphis rumicis Linnaeus.—*A. rumicis* has often been collected in New Brunswick and Prince Edward Island. In addition to the hosts recorded by Burnham (1938), collections have been taken from *Viburnum trilobum* Marsh., July, 1950 and *Philadelphus* sp., June, 1949, at Fredericton, N.B.; *Helianthus* sp., August, 1936, at O'Leary, P.E.I.; *Cosmos* sp., October, 1949, at Fredericton, N.B.; *Arctium minus* Schk., July and August, 1950, at Fredericton and Rexton, N.B.; and *Chenopodium album* L., July, 1949 and July, 1950, at Fredericton, Nashwaaksis, Keswick, Woodstock, and Maugerville, N.B.

Aphis sambucifoliae Fitch.—Alate and apterous viviparous females of this species were collected from *Sorbus aucuparia* (L.) at Pokiok, N.B., in October, 1949. Oviparous and alate females and alate males were collected from *Sambucus* sp. at Fredicton, N.B., on October 18, 1949.

Aphis sanborni Patch.—Burnham (1938) recorded this species. The specimens were taken in flight during June, 1937. Host and locality records are not available.

Aphis spiraecola Patch.—Alate and apterous viviparous females of this species were collected at Fredericton, N.B., on July 11, 1950, from *Spiraea tomentosa* L.

Aphis varians Patch.—Alate viviparous females of *A. varians* were collected from *Ribes aureum* Pursh. at Fredericton, N.B., on July 19, 1950. Many of these specimens were parasitized.

Aphis viburnicola Gillette.—This species has been collected from *Viburnum trilobum* Marsh. at Fredericton since 1937. Oviparous females were collected on October 20 and November 3, 1949; fall migrants and apterous viviparous females from September 26 to October 20, 1949. It has also been found during May and June on the same host, but is absent from this host between July and September, its summer host being unknown.

Aphis viburniphila Patch.—Apterous viviparous females of this species were collected at Stanley, N.B., from *Viburnum opulus* L., July 16, 1949.

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Establishment of *Exenterus* Spp. (Hymenoptera: Ichneumonidae), Parasites of the European Spruce Sawfly, Near Points of Introduction[1]

By W. A. Reeks[2]

Introduction

Several species of parasites have played an important part in the biological control of the European spruce sawfly, *Gilpina hercyniae* (Htg.), in the Maritime Provinces. Most of the parasites were collected in Europe by the Imperial Institute of Entomology (9), and some material was collected in Japan through the cooperation of the United States Bureau of Entomology. The parasites were reared or propagated by the Dominion Parasite Laboratory, Belleville, Ontario (12), and liberated by officers of the Dominion Entomological Laboratory, Fredericton, assisted by other government and company services.

The severe sawfly outbreak ended rather suddenly, and from about 1940 onward the insect occurred in only small numbers in most areas. A virus disease was the principal factor in ending the outbreak (2), but small mammals and introduced parasites contributed to the control of the sawfly. Native parasites destroyed less than 1 per cent of the sawfly population (11). Some of the introduced species of parasites have been of particular value in maintaining the sawfly population at low levels after the outbreak period.

At least seven species of introduced parasites have been reared from field-collected sawfly material. This paper deals with the recovery of parasites of the *Exenterus* group, particularly *E. claripennis* Thomson, with emphasis on its behaviour in areas where its establishment was studied intensively. The recovery of other species and their control value will be discussed in later papers.

Most of the investigations were carried out in a study area at Young's Brook, York County, N.B. These were supplemented with observations in the centre of the Gaspé Peninsula, P.Q., and records of the Forest Insect Survey.

Species of *Exenterus* Liberated

When the introduction of parasites of the genus *Exenterus* was commenced in 1933, several species were not well known. Identifications were confused

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TABLE I.

Liberations of *Exenterus* spp. at Young's Brook, N.B., and Upper Grand Cascapedia River, Province of Quebec.

Year	Number liberated	Names under which colonies were liberated	Probable species in colonies liberated	Location
1933	140	*E. marginatorius*	*E. claripennis*	Grand Cascapedia River
1936	435	*E. adspersus*	*E. amictorius* *E. claripennis* *E. vellicatus*	Young's Brook
1936	2,100	*E. abruptorius*	*E. abruptorius*	Young's Brook
1937	1,495	*E. adspersus*	*E. amictorius* *E. claripennis* *E. vellicatus*	Young's Brook
1937	23	*E. tricolor*	*E. tricolor*	Young's Brook
1937	463	*Exenterus sp.*	*E. claripennis* *E. amictorius* *E. vellicatus*	Young's Brook

until 1940, when Cushman (4) revised the genus. Additional synonymy was recorded in 1943 (5). One of the species recovered was not described until 1940, and it is likely that some of the first colonies that were released contained more than one species, as indicated by Baird (1).

Despite the early confusion in the taxonomy of the group, a study of specimens retained from the liberations and of specimens recovered shows that the following species have been liberated in the Maritime region: *Exenterus claripennis* Thomson, *E. amictorius* Panzer, *E. tricolor* Roman, *E. adspersus* Hartig, *E. vellicatus* Cushman, and *E. abruptorius* (Thunberg).

The present study is concerned principally with the Young's Brook and the central Gaspé liberations. These are summarized in Table 1. The colonies released as *tricolor* and *abruptorius* were undoubtedly correctly identified. The identity of the colonies liberated as *adspersus* is very questionable. Cushman (4) concluded that all American references to *adspersus* from 1936 to 1940 should be listed under *marginatorius*, which later (5) was shown to be a synonym of *amictorius*. Cushman based this opinion largely on an examination of specimens that were reared from Canadian sawfly material. More recent evidence suggests that at least three species have been released as *adspersus*. The writer examined eight specimens retained from colonies released as *adspersus* and found that they represented equal numbers of *amictorius* and *claripennis*. Specimens were recovered following a liberation at another point in New Brunswick, Canaan River, where the parasites were released as *adspersus*. The specimens subsequently recovered were *vellicatus* and *claripennis*. It is evident, therefore, that the *adspersus* liberations at Young's Brook refer to mixed lots containing *amictorius*, *claripennis*, and *vellicatus*. Although *adspersus* was released in New Brunswick, it was almost certainly not released at Young's Brook, as this distinctive species would have been recognized. The identity of the specimens released as *Exenterus* sp. is not known, but they seem to have consisted largely of *claripennis*, and

smaller numbers of *amictorius* and *vellicatus*. These were the species recovered, as shown below.

Of the above species the following have been recovered from the sawfly in the Maritime Provinces: *claripennis*, *amictorius*, *vellicatus*, and *tricolor*. A specimen of *tricolor* reared in 1946 was the only recovery of this species in the Maritime Provinces. Baird (1) has reported recovery of *adspersus* in Quebec, but this was before Cushman's revision. The species recovered in largest numbers at Young's Brook over a 4-year period were *claripennis* and *amictorius*, which occurred in the ratio of 20:1. The only other species recovered in this area was *vellicatus*, which was represented by four specimens. In the Cascapedia district, *claripennis* was the only species recovered. Extensive studies demonstrated with reasonable certainty that none of these species was present in the Maritime Provinces or Central Gaspé prior to these introductions from Europe (11).

Methods

The stand selected for study at Young's Brook consisted largely of white spruce, *Picea glauca* (Moench) Voss, and balsam fir, *Abies balsamea* (L.) Mill. The spruce were even-aged, averaging about 70 years of age.

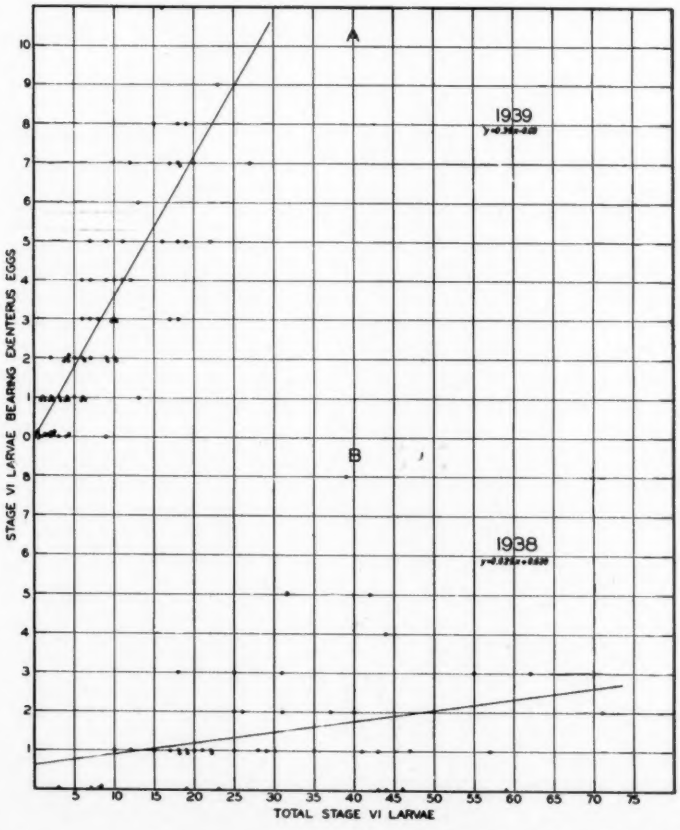

FIG. 1. Correlation between total sixth instar larvae (healthy, diseased, and dead) that dropped on 2- by 2-foot trays and number bearing *Exenterus* eggs. A, 1939. B, 1938.

Two methods were used for sampling the populations of host and of parasites. One consisted of recording the drop of larvae on trays erected beneath spruce trees (2). Each tray measured 2 by 2 feet inside, and was made with wooden sides and wire screen or cotton bottoms. The inside margin of the tray was coated with tree tanglefoot to prevent the escape of the larvae that fell on the tray. The trays were placed about one foot from the trunk of the selected trees, with the inner side at right angles to the radius of the tree. Forty-four trays were used in 1937 and 1938, and 80 from 1939 to 1941 inclusive. The trays were generally examined daily, and each larva removed from the trays was examined closely for *Exenterus* eggs, which are laid on the integument of the host. Parasitized larvae were reared for subsequent identification. This method provided a sample of the population of parasitized and unparasitized sixth instar larvae. The sixth instar is the best for estimating the parasite egg population because it is the only stage that normally drops from the tree, and at the time of dropping it has been fully exposed to possible attack.

The second method was applied to the measurement of the host-parasite population in the cocoon stage. This was essentially the same as "Method 2. Sampling a Restricted Universe", as described by Prebble (10). Four sampling units, each 2 by 2 feet were staked out beneath each of 100 dominant or co-dominant white spruce trees. One unit under each of 50 trees, was examined each spring as soon as the ground was thawed. Thus the 100 trees permitted sampling in undisturbed ground for eight years. After the ninth year the trees were used over again. The moss, duff, or humus was thoroughly examined for sawfly cocoons and replaced. All sound cocoons were reared, and the parasites that emerged were retained for determination.

A supply of parasitized larvae or cocoons for biological studies and parasitism was obtained by trapping the sixth instar larvae as they fell from the trees to spin cocoons. This was done by erecting a large cotton funnel, 10 by 10 feet, at the base of each of two trees. A metal barrier at the top of the funnel prevented the escape of larvae. Larvae that fell into the funnel were directed by gravity into a rearing compartment, which was filled with moss for spinning. Every three or four days the cocoons were removed and placed in boxes embedded in moss outside for parasite emergence.

Data on spread were obtained by collecting random samples of sawfly cocoons at measured distances from the nearest liberation point. The collections were reared for parasite emergence.

Life History

Some aspects of the life history and habits of the most common of the species of *Exenterus* have been described in several papers (3, 6, 9, 12). The following is a brief outline of the seasonal history of *claripennis* at Young's Brook. The life histories of *amictorius* and of *vellicatus* are similar but fewer data were obtained for these species.

E. claripennis, like its host, has one and a partial second generation per year in this district. Emergence of the overwintering generation occurred in late June and early July, and followed that of the sawfly by about ten days to two weeks. By the end of the parasite preoviposition period of several days most of the host larvae were sufficiently developed for attack by the parasite. Eggs were laid externally on fifth and sixth, and occasionally fourth instar larvae. The egg normally hatched within the host cocoon. The parasite larva fed externally on the eonymph, pronymph, or pupa within the host cocoon, and passed through five larval instars. The development of the larvae of the summer generation (with the exception of those that remained in diapause) required about 30 days,

TABLE II.

Emergence of *E. claripennis* from Spruce Sawfly Cocoons spun by field-collected Sixth Instar Larvae, Young's Brook, N.B.

Sawfly cocoons				Emergence of *E. claripennis*			
				First Year		Second Year	
Period Spun	Generation	Total No.	No. parasitized	%	Mean date	%	Mean date
July 5—Aug. 16, 1938.....	1	282	11	55	Aug. 26	45	June 30
Aug. 17—Oct. 4, 1938	2	317	39	0	—	100	July 1
July 15—Aug. 16, 1939.....	1	532	279	48	Sept. 3	52	June 28
Aug. 17—Oct. 4, 1939.....	2	1	0	0	—	0	—

most of the adults emerging in August. Approximately 50 per cent of the summer generation remained in diapause until the second year (Table 2), compared with about 75 per cent for the sawfly in this area. One parasite was in diapause two full years. The most common overwintering stage was the last instar or prepupa but the younger larval stages and the egg were also capable of overwintering. Male and female adults occurred in the field in almost equal proportions. Adults lived as long as two months under cage conditions.

Population Trend

The parasite population is shown in two ways: As the number of eggs on healthy sixth instar sawfly larvae, (i.e., parasitized larvae), that fell on the trays; and as the number of parasitized sawfly cocoons collected from the sample

TABLE III.

Population of Sawfly Cocoons and Healthy Sixth Instar Larvae and of *Exenterus* per Unit Area (2′ x 2′). Young's Brook, N.B.

Year	Healthy sixth instar sawfly larvae		Sound sawfly cocoons	
	Total	Parasitized by *Exenterus*	Total	Parasitized by *Exenterus*
1936	—	—	31.80±2.46	0.00
1937	55.54±4.78	0.04±0.03	66.68±6.08	0.00
1938	30.17±2.44	1.45±0.23	95.80±7.70	1.46±0.22
1939	8.28±0.73	2.96±0.32	28.66±2.80	0.84±0.24
1940	0.43±0.08	0.15±0.05	0.86±0.16	0.02±0.02
1941	0.07	0.00	0.00	0.00
1942	—	—	0.04	0.00
1943	—	—	0.04	0.00
1944	—	—	0.02	0.00
1945	—	—	0.16	0.04*
1946	—	—	0.08	0.02**
1947	—	—	0.00	0.00
1948	—	—	0.04	0.00
1949	—	—	0.20	0.02*
1950	—	—	0.04	0.02*

* *E. vellicatus*
** *E. claripennis*

quadrates beneath the trees. In the presentation of these data (Table III) the cocoon samples have been predated one year. For example, the counts made in the spring of 1937 are used to represent the 1936 population of parasite and host. In comparing the results of the two sampling methods it must be realized that the larval and cocoon samples are not strictly comparable although the sizes of the sampling unit were the same for both series of samples. The cocoon samples tended to be larger because they contained fractions of earlier generations in diapause. The parasite populations were similar in 1938 in the two types of sample. In 1939 and 1940 the parasite population tended to be higher in the larval sample than in the cocoon samples. This difference was perhaps due to inadequate sampling. However, the cocoons were exposed to mammal predators, which may have reduced the parasite numbers in the cocoon samples.

The peak of the population of the sawfly larvae in the Young's Brook area occurred in 1937. From that year the numbers declined annually until this phase of the work was discontinued at the end of the 1941 season. The peak of the sawfly cocoon population occurred in 1938, a year later than that of the larval population. This lag was due to diapause. The cocoon population was low after 1940, but slight annual fluctuations occurred until 1950.

The parasites were released prior to the peak of the sawfly numbers, and it is clear that the highest population occurred during a period of declining host population (Table III). The peak of the parasite population, based on larval samples, occurred in 1939. This indicates rapid establishment as it was only three years after the initial liberation in 1936. The highest population of *Exenterus* in the cocoon samples occurred in 1938, and from that year onward the population declined rapidly with that of the sawfly.

The data (Table III) show that the sampling was adequate only at high levels of population but it was impossible to extend the scope of the work.

Factors Affecting Establishment

Although the rise and fall of the parasite population was associated with the abundance or the scarcity of the sawfly, other factors contributed to the fluctuations in the numbers of the parasites. Some of these factors that adversely or favourably affected the establishment of *Exenterus* are discussed as follows:

Dispersal

The highest parasitism occurred at the immediate points of liberation. Two years following liberations, the parasitism at two of the Young's Brook liberation points amounted to 52 per cent of 532 cocoons collected. These cocoons were spun by larvae that fell on two funnels erected beneath spruce trees. The presence of *Exenterus* eggs on sawfly larvae showed that the parasites reached the main study plot, which was about 250 to 600 yards from the liberation points, one year following the first liberation in 1936. Two years following the initial liberation, the parasites were fairly uniformly distributed throughout the plot.

Dispersal was rapid. Sawfly cocoons were collected at measured distances from liberation points at Young's Brook and in the Gaspé. The total numbers collected for this purpose in the two areas were 34,986 and 28,417, respectively. The greatest known distance that *claripennis* spread from the Young's Brook liberation points was about 12½ miles. This was only four years after the initial release. Dispersal beyond that point could not be determined because of the proximity of collections to other liberation points. The greatest known distance of dispersal in the Gaspé was five miles, ten years following the initial liberation. These records indicate that dispersal was more rapid in a two-generation than in a one-generation area.

Rapid dispersal is a desirable quality in an introduced parasite species if it is accompanied by a high rate of reproduction and does not interfere with mating. The *Exenterus* group possesses both of these characteristics but the parasites' rapid dispersal may have tended to delay attainment of maximum effectiveness on the study plot.

Reproductive Potential

The parasites oviposit readily in laboratory and field cages, but it appears that they do not lay their full complement of eggs under artificial conditions. The egg capacity of *claripennis* was not determined. The maximum number of eggs laid by *amictorius* in cages was 102 per female. The latter species is apparently synovigenic, ovigenesis not being completed before oviposition begins (7). Dissections of gravid females showed nearly 200 oocytes in all stages of development. Perhaps all of these would not normally be laid, but probably the reproductive potential is closer to 200 than to 102.

Since the sexes of *claripennis* occurred in the field in about equal proportions, and assuming that this species and *amictorius* have the same egg capacity, then the reproductive potential might be expressed as: $0.5 \times 200 = 100$. The host, with its thelytokous parthenogenesis and egg capacity of 45 eggs per female (2), would have a reproductive potential of $1.0 \times 45 = 45$. Acknowledging that the population of both host and parasite is affected by many factors, there is at least some evidence that under favourable conditions the reproductive potential of *Exenterus* is about twice that of its host. Certainly the reproductive rate of *Exenterus* must be high, otherwise the population could not have built up as rapidly as it did in 1938 and 1939 (Table III). The high biotic potential apparently was one of the most important factors in the successful establishment of these parasites.

Host Ecdysis

The percentages of fourth, fifth, and sixth instars of sawfly larvae bearing *Exenterus* eggs, based on the examination of larvae collected from the trays in 1939, were 0.3 per cent, 9.7 per cent and 35.0 per cent respectively. These values do not necessarily represent successful parasitism. Of 241 field-collected, parasitized fifth instar larvae reared individually in cages outside, 59 per cent of the eggs were sloughed off with the final larval molt; seven per cent hatched while the host was still in the fifth instar and were likewise sloughed off, and 34 per cent survived. The survival of eggs on sixth instar larvae, and their successful rearing to the adult stage, approached 99 per cent, except when the host died from disease. Most of the parasitism shown in Table III, therefore, may be considered as successful parasitism.

Abundance of Other Hosts

The diprionines are the preferred hosts of the *Exenterus* group, but sawfly larvae of all species that fell on the trays were examined for the presence of *Exenterus* eggs. The most prevalent species, with the exception of *G. hercyniae*, were *Pikonema alaskensis* (Roh.), *P. dimmockii* (Cress.), and small numbers of *Neodiprion abietis* Harr. There were no cases of parasitism of these by *Exenterus*.

Since 1937, the Forest Insect Survey has been collecting and rearing many species of forest insects. The diprionines are not well represented in the maritime region, only seven species having been reared. Among these rearings were two records in 1947 of *claripennis* parasitizing *N. abietis* in New Brunswick. These are the only maritime records of any species of *Exenterus* attacking any host other than *G. hercyniae*.

It is apparent that the species of *Exenterus* recovered from G. hercyniae preferred this species to native defoliators of spruce.

Host Density

To the end of 1940, 95 per cent of the parasites recovered were *claripennis* and the remainder were *amictorius*, and their establishment was associated with a high but steadily declining sawfly population. The numbers of sixth instar larvae bearing *Exenterus* eggs were plotted against the total numbers of sixth instar larvae collected from the trays in 1938 (Figure 1, B). The correlation was only fair (P=0.05), but at that time the parasites had not become uniformly distributed. In 1939 the parasites had spread more uniformly throughout the stand. The sawfly larval population had declined to about eight per tray, but the parasites' numbers per tray showed about a two-fold increase, and a higher proportion of the sawfly larvae was parasitized than in 1938 (Figure 1, A). The correlation between the numbers of sawflies and parasites per tray was more significant in 1939 (P = 0.01). Thus, in each year up to 1940 the relation between the two populations was fairly uniform throughout the stand.

Following 1941 the sawfly population had reached such a low level that it was impracticable to continue observations on the abundance of parasitized larvae, but the annual sawfly cocoon counts were continued (Table III). From 1941 to 1944 no specimens of *Exenterus* were recovered, and it was believed that the parasites would be unable to maintain themselves if the annual sawfly cocoon population was consistently less than one per four square feet of forest floor. However, parasites reappeared in the samples in 1945, and from that year onward all recovered parasites were *vellicatus*, with the exception of one specimen of *claripennis*. Although the numbers were small, a similar succession of these species was shown in records of the Forest Insect Survey. The survey data were collected without regard to proximity to liberation points, so they will be discussed in more detail in a later paper. These records indicate that *vellicatus* differed from its related species in its ability to become established and maintain itself when the sawfly population was extremely low.

The densities of the sawfly and of the parasites' populations were affected by small mammals. Morris (8) has shown that some species of shrews or mice can readily differentiate between sound spruce sawfly cocoons and empty ones. The latter included cocoons from which adults of the sawfly or *Exenterus* had emerged. The finest degree of selectivity was exhibited in the shrew, *Blarina brevicauda pallida* Smith. This and some other less sensitive species were unable to distinguish between unparasitized cocoons and those containing the eulophid parasite, *Dahlbominus fuscipennis* (Zett.). Therefore, it would appear that equal proportions of cocoons parasitized by *Exenterus* and sound cocoons are opened by mammals.

It has been estimated (2) that approximately 80 per cent of sound sawfly cocoons in the Young's Brook area were opened by small mammals. Also, there is evidence that some sixth instar larvae were eaten by mammals before they had an opportunity to spin. If small mammals fail to distinguish between unparasitized and parasitized cocoons one would expect the number of parasitized cocoons collected from the plot to be appreciably smaller than the number of healthy sixth stage larvae bearing *Exenterus* eggs. A comparison of the two series of data (Table III) shows that there was no appreciable difference between parasitized larvae and parasitized cocoons in 1938. However, in 1939 and 1940 the differences were more striking, and it may have been partly due to mammal predators that *Exenterus* occurred in smaller numbers in the cocoon samples.

Balch and Bird (2) discussed the mortality of sawfly larvae by a virus disease in the Young's Brook area. They showed that the percentage of diseased larvae that dropped on 44 trays for the years 1939, 1940, and 1941 were 58.1

TABLE IV.

Seasonal Distribution of Average Number Spruce Sawfly Sixth Instar Larvae (healthy, diseased, and dead) and Percentage per Tray, bearing *Exenterus* Eggs, Young's Brook, N.B.

Period	1937		1938		1939		1940		1941	
	Av. No. larvae per tray	% Parasitism	Av. No. larvae per tray	% Parasitism	Av. No. larvae per tray	% Parasitism	Av. No. larvae per tray	% Parasitism	Av. No. larvae per tray	% Parasitism
July 1— 6	0.1	0	0	0	0	0	0	0	0	0
July 7—14	2.8	0	0.1	0	0.1	50.0	0	0	0	0
July 15—21	11.8	0	0.7	0	0.4	35.7	0	0	0	0
July 22—28	16.0	0	2.0	4.6	2.5	41.3	0.1	0	0.1	0
July 29—Aug. 4	5.4	0	2.6	0	4.4	36.1	0.1	11.1	0.1	0
Aug. 5— 8	3.3	0	2.4	0	1.7	14.4	0.1	37.5	0.1	0
Aug. 9—11	1.8	0	1.3	0	0.3	13.6	0.1	20.0	0	0
Aug. 12—18	0.9	0	3.3	0	0.2	15.3	0.2	52.9	0	0
Aug. 19—26	1.1	0	1.0	0	0.1	0	0.1	0	0	0
Aug. 27—Sept. 1	1.5	0	1.3	0	0.1	0	0	0	0	0
Sept. 2— 9	1.7	0	1.1	6.4	0.1	0	0	0	0	0
Sept. 10—14	3.2	0	2.6	7.7	0.1	0	0	0	0	0
Sept. 15—26	1.0	5.3	6.3	13.0	0	0	0	0	0	0
Sept. 27—29	0.8	0	1.4	3.3	0	0	0	0	0	0
Sept. 30—Oct. 7	0.5	0	1.8	10.0	0	0	0	0	0	0
Oct. 8—11	0.5	0	0.6	7.4	0	0	0	0	0	0
Oct. 12—24	0.8	0	1.6	1.4	0	0	0	0	0	0

Note: Parasitism refers to larvae bearing *Exenterus* eggs.

per cent, 94.2 per cent, and 86.2 per cent, respectively. Corresponding percentages of parasitized larvae that were diseased (all instars) were not recorded by these authors, but they were 8.1 per cent, 52.1 per cent, and 100.0 per cent.

The disease affected the population increase of *Exenterus* by reducing the host population and by killing parasitized larvae. The most serious effect was the almost complete destruction of sawfly larvae during the period of second generation parasite adults. This effect is indicated in Table IV, which shows the percentages of parasitism at intervals of a few days. Both the host and the parasites passed through one and a partial second generation. Although there was an overlap of generations, August 15 would roughly separate the two generations of *Exenterus* in the egg stage. As there was only slight mortality from the disease in 1938, the behaviour of the parasites that year can be considered as normal in the absence of disease. In 1938, parasitism was light during the first generation and was highest during the second generation. In subsequent years, when the disease was more virulent, parasitism was high during the first generation, and negligible during the second generation due to the virtual absence of living sawfly larvae. Most of the second generation sawfly larvae from 1939 to 1941 were killed by the disease. None reached the sixth instar (Table IV), and only a few reached the fifth instar. As indicated previously, these are the instars on which the parasite eggs are generally laid.

Extermination of *Exenterus* in one season was prevented by diapause. Approximately half of the first generation of *Exenterus* in 1938 and in 1939 produced second generation adults (Table II). There is little doubt that these were a complete loss in the perpetuation of the parasite during the period of high virulence of the disease. Mean dates of second generation *claripennis* emergence in these two years were August 26 and September 2, at which time there were no living host larvae sufficiently advanced in development for attack by the parasite. Apparently it was the portion of the parasite population in diapause that enabled *Exenterus* to survive the unfavourable conditions created by the disease.

Under cage conditions *claripennis* adults would lay many eggs on one sawfly larva. This condition occurred only rarely in the field. Of field-collected larvae bearing *Exenterus* eggs, about 1 per cent bore more than one egg.

Multiple parasitism also occurred rarely. During the several years of observation there were three or four cases of spruce sawfly cocoons containing larvae of *claripennis* and *Dahlbominus fuscipennis* (Zett.). The latter was successful over *Exenterus*. There have been occasional instances of sawfly larvae bearing *Exenterus* eggs also being parasitized by one of the two tachinid parasites: *Drino* (*Prosturmia*) *bohemica* Mesnil and *Bessa harveyi* (Mg.). These tachinid parasites were also successful over *Exenterus*. Neither superparasitism nor multiple parasitism occurred frequently enough to lower appreciably the host density or affect the establishment of the parasites.

Summary

Of six species of *Exenterus* parasites introduced into Eastern Canada, four have been recovered from *G. hercyniae* (Htg.) in the Maritime Provinces. The recovery of these near liberation points is discussed, with emphasis on *E. claripennis*. Populations of the parasites were measured by counting the number of parasitized last instar larvae that fell on trays and parasitized cocoons collected from unit areas of forest floor. *E. claripennis* was the predominant species recovered until the host population of larvae or cocoons dropped to about one per 4-sq. ft. sample. At lower populations *E. vellicatus* predominated, although

Note: Parasitism refers to larvae bearing *Exenterus* eggs.

the numbers were small. After becoming established in a stand the population of the parasites tends to vary directly with that of the sawfly. Factors that affected parasite numbers are discussed. The most important was a virus disease of the sawfly larvae. After 1938, the disease destroyed most of the host larvae during the period that second generation parasite adults were present in the field. Extermination of the parasites was prevented by diapause, which enabled part of them to carry over the unfavourable period until the following year.

Acknowledgments

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The Spruce Bud Midge, *Rhabdophaga swainei* Felt (Cecidomyiidae: Diptera)[1]

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In May, 1948, numerous malformed buds were collected from young spruce trees at Fredericton, N.B. These enlarged buds were about 7 mm. long and 4 mm. in diameter, with lateral scales reflexed and their rosette-like apices loose and open. Dipterous adults emerged in a few days and their identification as *Rhabdophaga swainei* Felt was confirmed by G. E. Shewell, Systematic Unit, Division of Entomology, Ottawa.

The only references in the literature are Felt's (1) original description of the adults and a mention of the gall by the same author (2).

The following notes are based on field observations made at intervals through 1948 and early 1949 near Fredericton, N.B.

Description

The adult is typical of the family, with hunched thorax and long legs. The body colour of the male is reddish-brown. The female has a reddish-brown thorax but its abdomen and conspicuous ovipositor are bright orange-red. Felt (1) gives detailed descriptions of both adults.

The egg is 0.4 to 0.5 mm. long; elongate oval, about four times as long as broad; straight or slightly curved, pale orange-pink with an internal red spot near one end; chorion soft, transparent, smooth, and very shiny.

The second instar larva is 0.3 to 0.4 mm. long, spindle-shaped, reddish-pink, translucent, and smooth. The full-grown larva is 1.5 to 2.2 mm. long and 0.5 to 1.0 mm. broad, spindle-shaped, pale pink; segmentation apparent, with 13 segments. In the prepupal stage, it is somewhat shortened and thickened.

The pupa is 1.5 to 2.5 mm. long; it appears free but is actually enclosed in a very delicate, transparent case. Coloration of the pupae is similar to that of the adults. The pupa is contained in a hardened cell in the heart of the gall.

Habits and Life History

The eggs are deposited deep down between the resinous basal scales or between the crowded young needles of the developing shoot. Egg laying was observed from May 5 to 26, 1949, during which time the buds of white spruce burst and shoots elongated 1 to 3 inches. Microscopic examination of five twigs on which oviposition had been observed, showed that one had a cluster of seven eggs, one had two and the remainder one egg each. Dissection of an adult female showed nine fully formed eggs in the oviduct. It was noted that a female would visit several shoots and, in each case, insert the ovipositor between the basal scales or young needles. Oviposition was observed most frequently during sunny periods. This heliophilous tendency of the adult female explains the fact that galls are most numerous on the sunny sides of open-grown trees.

The incubation period is about five days under laboratory conditions. The newly-hatched larva crawls to the tip of the elongating shoot and enters it by boring through the soft base of a young needle. Little is known of the insect's development in the bud. The early feeding must be very limited, however, as the current shoot completes its development and the buds appear normal until late fall or early winter. Dissection of galled buds in late November, 1949, showed the larvae to be almost fully grown but dormant, which suggests that the

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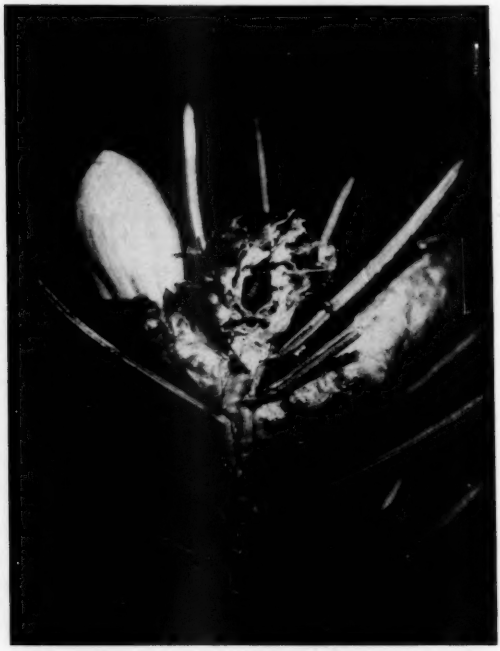

FIG. 1. Twig of white spruce with a terminal bud gall formed by the spruce bud midge. The side of the gall is removed showing the larva within. Note development of a normal bud on the left. (Photo by W. A. Reeks)

insect overwinters in this stage. By May 29, 1948, and May 5, 1949 (the spring of 1949 was early in Fredericton), only pupae were found in the galls.

Toward late April the galled bud becomes rosette-like due to drying and recurving of the bud scales. This exposes soft, pale, papery, inner scales at the gall apex, no doubt facilitating the emergence of the adult. The adult, while still in the pupal stage, vacates the gall cell by pushing itself outwards with a rocking movement. It then emerges from the fragile pupal case which is usually left protruding from the gall apex. In 1948, adults were observed emerging from June 1 to 4; some empty galls were found, however, indicating that adults were in flight prior to that period. In 1949, adults were observed in flight from May 5 to 26. There is one generation per year.

A chalcid parasite commonly found inside the gall was identified as *Amblymerus* sp. by O. Peck, Systematic Unit, Division of Entomology.

Hosts and Distribution

The spruce bud midge is common on both white spruce, *Picea glauca* (Moench) Voss., and red spruce, *P. rubens* Sarg., although attacks on the former are by far the heavier. Black spruce, *P. mariana* (Mill.) B.S.P., seems to be immune, possibly because its buds burst after the flight of adult midges is over. Numerous galls were found on Norway spruce, *P. abies* (L.) Karst, and a few have been noted on Colorado blue spruce, *P. pungens* Englm.

The spruce bud midge is common in central New Brunswick, but has been noted at widely scattered points throughout the Province. Galled buds of white

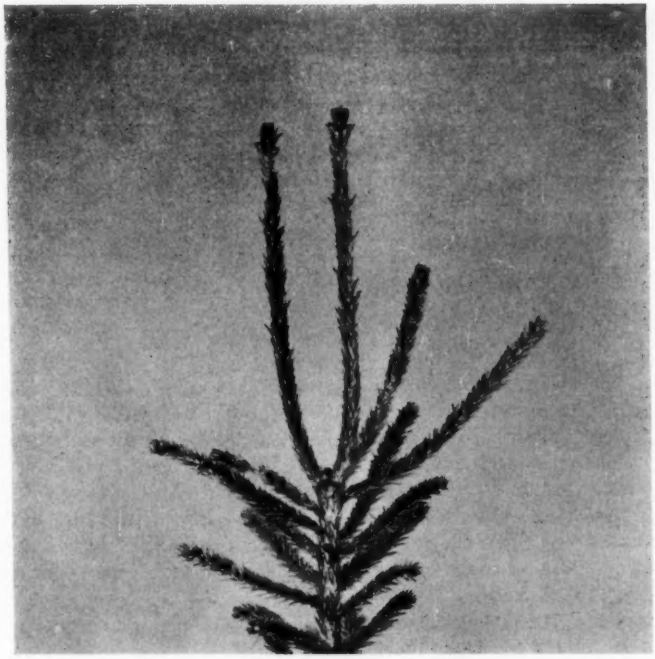

FIG. 2. Double leaders on a small white spruce after the leading bud was arrested by the spruce bud midge.

spruce were seen at various localities in Prince Edward Island in 1948 and in Newfoundland in 1948 and 1949, indicating wide distribution.

Effect on the Tree

Galls are most numerous on the sunny sides and tops of open-grown trees from 6 to 12 feet high. They are commonly, though not exclusively, formed on the terminal buds of branches. The attacked bud is completely arrested in its growth (Figs. 1 and 2); elongation of lateral buds the following year causes bushy growth. When the leading bud of a tree is attacked, a crook develops but this is no doubt overgrown before the trunk reaches pole size. In some cases multiple leaders result (Fig. 2).

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Effect of Time of Seeding Apex Wheat on Infestation and Sex Ratio of the Wheat Stem Sawfly, *Cephus cinctus* Nort. (Hymenoptera: Cephidae)[1]

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In 1945 a field experiment was designed at the Lethbridge laboratory to augment data on the effect of the time of seeding on infestation by the wheat stem sawfly, *Cephus cinctus* Nort. At that time one of the recommendations for the control of this insect was to delay seeding wheat until after May 15. The resulting crop escaped infestation because of the retarded plant growth during the period of the sawfly flight.

Methods

A site for plots was selected in the Coaldale area, about 15 miles east of Lethbridge. The plots were situated on summer-fallow adjacent to a field of wheat stubble that had been uniformly infested in 1944. Five rod-rows of Apex wheat were sown at approximately five-day intervals from April 30 to May 22 and daily after that date until June 9.

Single rows of each seeding were sampled at appropriate times to determine the number of eggs per stem, of stems infested, of stems cut, and of larval mortality. At the end of the season the stubs were removed to the laboratory for emergence of adults.

During the growing period agronomic data on plant emergence and time required for heading and ripening were also noted.

Results and Discussion

Early-seeded wheat always receives the full impact of sawfly infestation; a greater number of eggs are laid, resulting in a high percentage of infested stems and increased crop loss. In late-seeded crops the crown tillers may entirely escape infestation.

In sawfly control blocks in Alberta and Saskatchwean it had been observed that when infestations occurred in late-seeded fields the build-up of infestation did not come up to expectations the following year.

Evidence of the effect of the time of seeding in reducing sawfly infestation is shown in Table I, which is based on field data obtained in Saskatchewan by Farstad, King, and Glen (1944) and Farstad and Jacobson (1945).

TABLE I.
Percentages of infestation of wheat by the wheat stem sawfly for various dates of seeding. Data based on Farstad, King and Glen (1944) and Farstad and Jacobson (1945)

Seeding dates	No. of fields	Percentage infestation
April	39	62
May 1–13	281	56
May 14–20	228	40
After May 21	209	13

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Table II, based on the Lethbridge studies, shows the progressive decrease in the average number of eggs laid per stem, and in the percentages of stems infested and of those cut, as the seeding is delayed.

TABLE II

Agronomic data, and oviposition, infestation, and sex ratio data on the wheat stem sawfly in plots of Apex wheat seeded on various dates, Coaldale, Alberta, 1945

Seeding date	No. of days till			Average No. of eggs per stem examined	PERCENTAGE		
	Emergence	Heading	Ripening		Stem infestation	Stems cut	Males
April 30	12	65	104	7.7	100	61	43
May 5	11	62	99	5.3	100	72	40
10	10	58	95	2.5	95	71	54
12	10	59	95	2.9	95	74	52
16	8	58	92	4.0	95	74	54
22	6	53	87	2.3	83	65	61
23	5	54	86	2.7	88	78	51
24	6	54	85	2.5	90	66	67
25	5	55	84	1.9	69	54	70
26	5	55	84	1.1	48	41	72
27	4	56	84	1.1	70	45	69
28	6	56	84	0.7	35	28	83
29	10	56	85	0.3	32	29	69
30	9	56	85	0.5	23	17	74
31	9	56	88	0.0	8	2	78
June 1	11	55	88	0.0	0	2	0
3	9	55	86	0.0	0	0	0
9	7	51	81	0.0	0	0	0

Only after obtaining complete emergence of adults from the stubs collected from the plots at Coaldale was it possible to explain why expected increased infestations did not materialize the year following the application of delayed-seeding control. In Table II a progressive increase is noted in the ratio of males to females as the seeding date advanced.

Laboratory and field studies on *C. cinctus* have shown anomalous sex ratios. Farstad (1938) found certain districts adjacent to Lethbridge in which no males were found for several years. Farstad, Platt, and McGinnis (1950) reported marked differences in sex ratios of populations emerging from different varieties of wheat in areas in which the sex ratio from standard wheat varieties was approximately 1:1.

Unmated females, except those from limited areas in which a uniparental race exists, are known to produce a high preponderance of males.

Progressive increase in the proportion of males as the seeding date is delayed seems to be associated with the field behaviour of the insect. Males usually emerge first, and there is always an excessive number of females toward the end of the flight. It seems highly probable then that some of the later-emerging females lay infertile eggs, the females having emerged after the males have disappeared, or the sperm reserve being insufficient to carry through the entire oviposition period. Either of these conditions would contribute to an increase in the proportion of males in the late-seeded plots.

There are undoubtedly other environmental factors, such as nutrition, temperature, and location of plots, that might modify the sex ratio of biparental

species, but the data do not indicate that these were contributing factors in this instance.

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Book Review

***An Annotated Check List of the Macrolepidoptera of British Columbia*: By J. R. J. Llewellyn Jones. Pp. v, iii and 148. The Entomological Society of British Columbia, Occasional Paper No. 1: $1.00.**

For many years Mr. Llewellyn Jones has been known as a collector and earnest student of the British Columbian Macrolepidoptera. Both through his own efforts and through painstaking correspondence with entomologists who shared his interests, he has amassed a knowledge of his specialty that is second to none. The volume under review is in effect a summary of this knowledge. Locality and date records are given for about 1160 species, as well as for many subspecies and forms. Food-plant records are also given where available; many of these were previously unpublished. Common names are listed, on the basis of a compilation of the existing literature.

The author has evidently taken great pains not only in seeing that the list should be as complete and informative as possible but also in ensuring that it would be presented in attractive and useful form. The book is compact and printed on a good grade of paper; the arrangement follows that of McDunnough's check list, with modifications based on subsequent revisions, but where possible retaining McDunnough's serial numbers. There is a most useful geographically classified list of localities mentioned in the text, and there is an index of genera and higher categories.

What might in other hands have been a bare list of names, of limited value, has been made by Mr. Jones into a most valuable source of information. It will be of use to anyone interested in the ranges or life histories of North American Lepidoptera, and should be in every entomological library. Copies may be purchased from the Secretary, The Entomological Society of British Columbia, Livestock Insect Laboratory, P.O. Box 210, Kamloops, B.C.

EUGENE MUNROE.

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